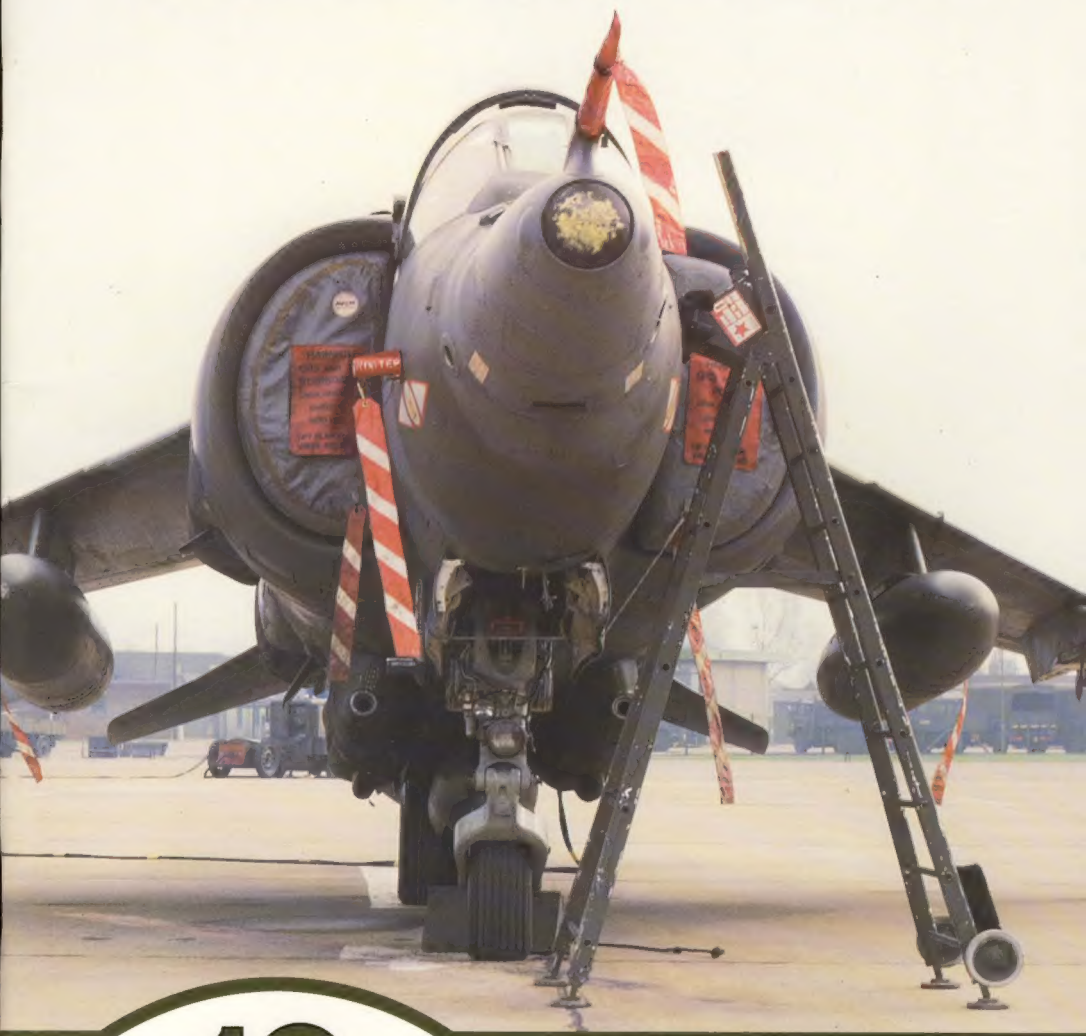
HARRIER



AERO GUIDE 12

Hawker Siddeley Harrier
GR Mk 3/T Mk 4

AEROGUIDE 12:
HAWKER SIDDELEY HARRIER
GR Mk 3/T Mk 4

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Cover photo: A Harrier GR Mk 3 of No 1(F) Squadron, RAF Wittering, February 1985.

Back cover plate: A Harrier GR Mk 3 wearing the markings of No 1453 Flight, RAF Stanley, Falkland Islands, late 1984.

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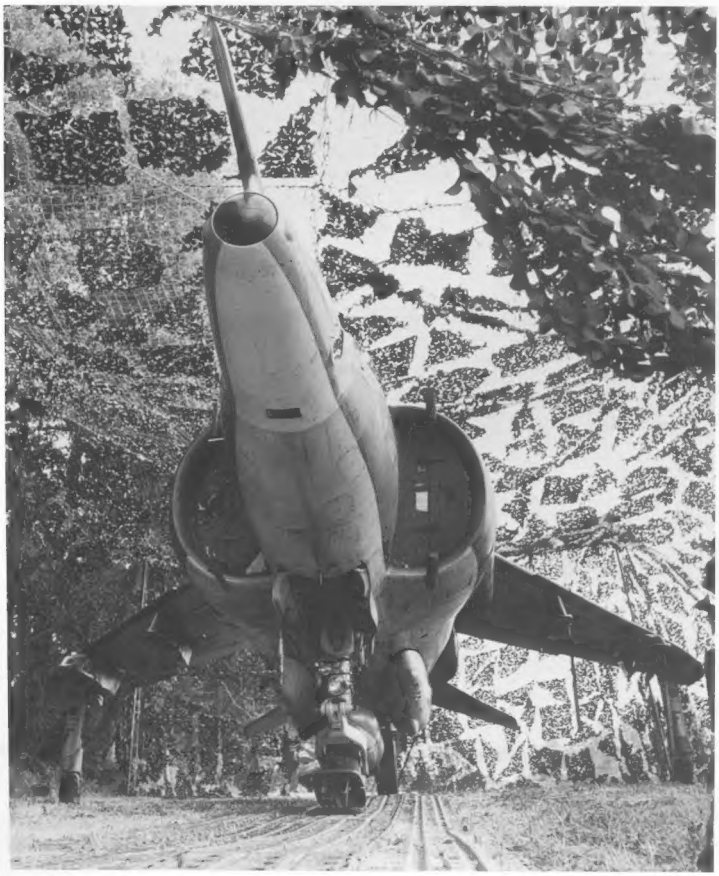
INTRODUCTION

Quite why only four of the world's nations have recognised the advantages of the Harrier to the extent of buying the hardware and placing it into service is doubtless a complex question, but to the layman it must rate as one of the major aviation mysteries of the age. It seems incredible to many that combat aircraft – the most flexible weapons of modern warfare – should be dependent for their operation on hundreds of yards of flat concrete for years targeted with pinpoint accuracy; as a corollary, since a situation could well develop wherein it is the only effective machine that survives into D+1, it also seems strange the Harrier is not filling service inventories across the globe to the point of overflowing.

Despite a service career now getting on for two decades, the Harrier and its derivatives are still the only aircraft of their kind in the world, notwithstanding the capabilities of the Yak-36 'Forgers' now lining the decks of Soviet aircraft carriers. No other fixed-wing aircraft can take off and land vertically (VTOL), conventionally (CTOL) or using minimum-length runways (STOL) from fixed strips, off-base sites or sea-going platforms, and carry out a wide range of missions including ground attack/close support, reconnaissance and (as specialities of the Sea Harrier) maritime strike and air-to-air combat. Most importantly, the aircraft has been put to the acid test – actual battle operations, and in the most ungenerous of environments at that – and has been marked A-plus, even by sceptics.

The road to success has been extremely bumpy (in common, it seems, with every other postwar British military aircraft project), and it is only thanks to the dogged determination of far-sighted individuals in the aircraft industry that the Harrier ever got beyond a sketch on a blotting pad. Back in 1957, it must be remembered, it was decreed by the British Government that manned combat aircraft would henceforth no longer be required and that everything necessary could be achieved by missiles, the new wonder weapons. The world into which the brilliant Harrier concept emerged was therefore not exactly welcoming, and it was only this gritty determination, helped along by continual American prodding, that enabled work on the P.1127 prototype to proceed.

Once the Harrier finally reached service status and proved its capabilities operationally, one might have assumed that future V/STOL projects would be rid of most of the traumas experienced with the P.1127; following the news that the United States Marine Corps would buy



Harriers from Britain (nobody could remember the last time a US service had bought a foreign aircraft 'off the shelf'), surely the final accolade had been bestowed and surely development would now proceed with all despatch? Not a bit of it. The Royal Navy, having been told some years earlier that its fixed-wing squadrons were going to be abolished, managed after a good deal of grumbling to get a handful of Sea Harriers for operation from its 'through-deck cruisers' (1960s vogue term for 'light aircraft carriers', devised to avoid upsetting politicians), but some marvellously inventive and practical ideas for future British V/STOL projects fell on deaf ears. A joint US/UK development programme for an advanced Harrier was rejected too, the Government talking vaguely about upgrading the existing fleet by fitting larger wings and other interesting details. Thankfully, Kingston had decided at an early stage to keep its hand in at company level with post-Harrier studies undertaken by McDonnell Douglas, whose continued research into V/STOL was producing some promising prototypes. The end product of this research, the AV-8B Harrier II, will be bought for the RAF, but there is no denying the fact that it is the St Louis-based manufacturer that now makes most of the running.

The Harrier has been around for a fair while, but it is still, so far as the public is concerned, a show-stopper. The sight of six tons of a metal hanging motionless (if exceedingly noisily) in mid-air is still incredible to behold, arguing as it does against the fundamental laws of nature. One day, perhaps, this spectacle will be routine for all military aircraft.

Opposite page: Not a manufacturer's publicity shot, but a photograph taken during Exercise 'Heath Fir', RAF Germany, in June 1976. Off-base dispersals are routine for all the Harrier squadrons, simulating actual conditions which would prevail in the event of war, and the preparation of such 'hides' in woodland clearings is frequently only a matter of putting up some camouflage netting and laying down pierced aluminium planking so that the aircraft can be run in and out. This No 4 Squadron Harrier GR Mk 3 has recently had its Ferranti laser equipment installed at the nose, the fresh paintwork contrasting with the rest of the airframe. *RAF Official*
Below: Intake 'blow-in' doors open, a GR.3 lifts off on a training sortie, 1978. The aircraft carries full 'wrap-around' camouflage, and although no unit markings are apparent it is assigned to No 3 Squadron, RAF Germany. *RAF Official*

DESIGN & DEVELOPMENT

More than any other aircraft, the Harrier is a product of its powerplant: the aircraft is unique because its engine is unique. The Rolls-Royce Pegasus operates on the principle of vectored thrust. Put crudely, instead of blasting hot gas in a straight line out of the back end, it directs the efflux through rotatable nozzles fitted along the sides. If the nozzles point aft, the aircraft moves forwards; pointed downwards, it rises vertically, with of course the proviso that the thrust produced by the powerplant exceeds the weight it is expected to move. Thus, unlike other aircraft (including helicopters), the Harrier does not need to generate lift aerodynamically in order to become airborne. The fact that it has a wing – necessary for conventional flight – gives it extra flexibility, in that rolling take-offs can be performed if required, by utilising the wing for lift in the traditional fashion. By combining aerodynamic lift and vectored thrust, the take-off distance is shortened or lengthened as the situation demands, although, in general, the greater the take-off weight (that is, the more weapons or gallons of fuel carried) the more important is the aerodynamic element.

The idea for the Harrier's vectored-thrust engine is usually ascribed to Michel Wibault, a Frenchman who made a considerable reputation for himself through a series of successful fighter designs between the wars. The British connection came about through his Gyroptère, a 1956 outline sketch for a VTOL aircraft which showed enclosed, swivelling compressors either side of the fuselage driven by a standard gas turbine. When Dr Stanley Hooker, Technical Director of Bristol Aero Engines, learned of the idea he was immediately impressed by its potential, and his engineering staff at Bristol set about developing and refining it. The result was the BE.52, in which the swivelling compressors were abandoned in favour of a single axial compressor (which would discharge through a pair of side-mounted moving nozzles) and a gas turbine (exhausting directly aft in the conventional fashion).

By now, mid-1957, the design staff at the Hawker company had become involved. Hawker Aircraft were at the time up to their eyes in studies for Hunter and Canberra replacements and, in common with aero concerns across the world, in projects for VTOL machines using batteries of vertically mounted lift jets. Chief Designer Sir Sydney Camm got to hear about Bristol's work on the BE.52 and passed the details to his colleagues at Kingston for their consideration. Within a matter of weeks a redesigned engine, the BE.53, had been drafted out, the original single jet pipe aft modified into a bifurcated pipe exhausting on either side of the fuselage. This arrangement was by no means novel, since Hawker's Sea Hawk was already flying off British carrier decks using just such a system; the difference was that the pipes terminated in moving nozzles, like the other two further forward. Suddenly an interesting STOL study became a very promising VTOL project.

In August 1957 the Hawker P.1127, a single-seat ground attack/reconnaissance aircraft powered by a BE.53, was officially drawn up. The ensuing months were spent revising and refining the design, the tight interdependence between airframe and powerplant requiring more than usually close co-operation on the part of their respective manufacturers. Predictably, scant Government support, even moral support, was forthcoming: the spring 1957 White Paper on defence, which saw the future role of the RAF as pushing buttons instead of flying combat aircraft, was not yet perceived for the nonsense it was, and Camm had a tough time persuading people to his point of view. In late 1957 work on the P.1127 stopped completely.

Not for the last time in the Harrier saga, the United States rode to the rescue. Here, in early 1958, it was in the form of the Mutual Weapons Development Program, a US-financed organisation dedicated to the support of European military projects that looked likely to go places given sufficient encouragement (= American money). Already well aware of (and very interested in) the V/STOL work under way in Britain, MWDP offered to foot 75 per cent of the cost of producing half a dozen BE.53s, and the future for Bristol's unique powerplant looked rosy.

The same could not be said for the airframe that Hawker wanted to build. Design work proceeded through 1958, Government assistance being limited to encouraging noises about wind tunnel facilities and hints that, on second thoughts, the day of the manned combat aircraft might not be over after all. The following year Hawker cast caution to the wind and made up their minds to go ahead and build two P.1127 aircraft anyway.

More US involvement came the next year, in particular when the National Aeronautics and Space Administration (NASA), supported by the US Air Force, agreed to provide facilities at its Langley, Virginia, establishment for the testing of P.1127 models. Then draft requirement GOR.345 appeared, detailing the need to design a new combat aircraft to replace the Hunter (again), and at long last, in October 1959, the British Government put its hand in its pocket and pulled out a cheque for £75,000, to cover design work thus far on the P.1127 project(!). Six months later Hawker were invited to tender for four 'development' P.1127s, and in June 1960, just as they were having the finishing touches put to them, the two private-venture aircraft were formally funded.

The P.1127's first 'flight' took place on 21 October 1960, the aircraft rising about a foot from the ground in a tethered vertical take-off. Early trials not unnaturally emphasised the radical VTOL technology, and once progress with this aspect of the programme was being satisfactorily made, attention turned to exploring the P.1127's taxying characteristics, followed by conventional take-offs. XP831, the first prototype, was joined by XP836 in June 1960, and the two machines began to attack the central question: could the aircraft carry out the crucial

Above right: The Hawker P.1127, the first successful application of the vectored-thrust principle. This is the first of the two prototypes, XP831, seen in August 1962. The black intake rims are inflatable rubber, to give extra radius for hovering flight, but this design feature was not pursued. Early flights of the P.1127 saw all unnecessary equipment – undercarriage doors, tail fairing, radio equipment etc – removed in a strenuous effort to save weight. *Richard L Ward*
Right: The third of the Government-funded P.1127s, showing some of the stages in the evolution of the design: faired wing root trailing edges, tailplane anhedral, 'kinked' wing leading edges, wing vortex generators and reconfigured, streamlined wing tips. The intake lips are fully inflated and the wing flaps are at full deflection. *British Aerospace*

airborne transitions between vertical and wingborne flight? For two months XP831 tackled the challenge from one end (VTOs) and its partner from the other (conventional forward flight). The transition was successfully demonstrated in September when the first prototype rose, swivelled its nozzles and soared away.

Meanwhile the BE.53 – now named Pegasus – had been receiving continuous attention. Originally run at 9000lb thrust, it was showing 11,300lb by the time the P.1127 first took to the air. A year later the Pegasus 2 was producing 12,000lb, enabling XP831 to start exploring STOL techniques, and by the spring of 1962 the aircraft was equipped with the 13,500lb Pegasus 3, with the promise of the Mk 5, of 15,000lb, in 1963.

A further four P.1127 prototypes were contracted for by the Ministry of Aviation late in 1961, but by this time any direct military application for the aircraft appeared to be fast receding as GOR.345 was cancelled and its place taken by NBMR-3. This was a scheme devised by NATO envisaging a supersonic strike fighter the chief feature of which would be the ability to clear a 50ft high obstacle after a take-off run of 500ft – in other words it would need to get its wheels off very smartly indeed. Hawker, as might be expected, saw distinct possibilities in this idea, especially as they had some months earlier produced a drawing for the P.1150. This advanced the P.1127 concept principally by introducing plenum-chamber burning (PCB), which would increase the thrust of the Pegasus in much the same way as an afterburner. The formal Hawker submission to NATO was the P.1154 (née P.1150/3), which, as it turned out, won the NBMR-3 nod.

The P.1154 programme is a saga in itself, but its impact on the P.1127 project was two-edged: on the one hand the latter represented extremely valuable trials technology for ironing out V/STOL problems; on the other, the juicy programme was clearly its supersonic offspring, since this was the aeroplane that would equip the squadrons – and possibly an awful lot of squadrons. Even so, a further development in the P.1127 story unfolded in May 1962, when sanction was given to Hawker to proceed with the

construction of a batch of nine more aircraft, to equip an evaluation squadron. Early the next year an agreement was reached involving Britain, the United States and West Germany for joint and equal sponsorship of this programme. The new aircraft, later christened Kestrel, was fitted with the Pegasus 5, showed some noticeable design modifications compared to the earlier P.1127s and carried a modicum of operational equipment. The so-called Tripartite Evaluation Squadron was formed at RAF West Raynham in 1964, operated by personnel drawn from the three nations. Flying began in earnest in the spring of 1965.

In January 1965 the P.1154 was killed off by the new Labour administration, but some oil was poured on the troubled V/STOL waters by the issue of ASR.384 – in effect a resuscitated GOR.345 – requiring a P.1127 development for eventual RAF squadron service. Six pre-production examples of what would come to be named the Harrier were ordered that year, and the first, XV276, flew in August 1966. Although directly descended from the Kestrel, and bearing a striking external resemblance to it, the Harrier was virtually a new aircraft. The next version of the Pegasus, the Mk 6, was earmarked for installation in service machines, bringing with it an increase in thrust to 19,000lb. A good deal of operational equipment – inertial nav/attack system, head-up display (HUD), head-down moving map display, 70mm sideways-looking camera – had to be crammed in, plus provision for external offensive loads and more fuel. The intakes had to be redesigned to accommodate the new engine's greater appetite for air, and the wings and the undercarriage had to be considerably beefed up.

The initial production version of the Harrier, the GR Mk 1, entered service with No 233 Operational Conversion Unit on 1 April 1969 – nearly thirteen years after Dr Hooker's historic encounter with Michel Wibault. A two-seat trainer, T Mk 2, had been contracted for in 1966 and first flew just as No 233 OCU was beginning to receive its single-seaters. A number of studies had been looked at, including machines fitted with side-by-side seating for student and instructor and even a twin-nose design, but the final drawings showed what was in effect a 'stretched' GR.1. The centre fuselage and wing were little altered, but an extra section carrying the second cockpit was introduced adjacent to the intakes, the additional weight being offset behind the engine by extending the fuselage in the form of a ballasted 'sting' and relocating and enlarging the tailfin.

Continued development of the Pegasus (under the management of Rolls-Royce since the Bristol/R-R merger) brought along the Mk 102 of 20,000lb thrust, a retrofit

Left: The first Hawker Siddeley Kestrel shows the complex insignia adopted for the Tripartite Evaluation Squadron. Kestrels had a camera fitted in the nose and could be equipped with a modest underwing load. Further substantial redesign had by now resulted in a 'humped' profile to the upper fuselage, a completely revised wing and a larger tailplane. *British Aerospace*
Top: Kestrel XS691 demonstrates its hovering capabilities. The strakes visible beneath the fuselage improved lift and were retained for the production Harrier. *British Aerospace*
Above: The definitive Harrier, showing the completely redesigned intakes fitted to production aircraft. The Aden cannon pods fitted beneath the fuselage have similar lift-enhancing qualities to the strakes. *British Aerospace*
Below: The first production Harrier T Mk 2 was retained by the manufacturers for weapons carriage trials; all Harrier trainers have full combat capability. *British Aerospace*

programme to all existing aircraft resulting in changes of designation to GR Mk 1A and T Mk 2A. From 1973 the 21,000lb Pegasus Mk 103 became available, and another retrofit re-categorised the aircraft as GR Mk 3 and T Mk 4. Coincidentally, the fitting of a laser rangefinder and marked target seeker (LRMTS) saw the Harrier sprout a nose extension, and radar warning receivers (RWR) were added to the fin leading edge and tail boom.

Export sales of the Harrier have been undistinguished, with one significant exception. Proposals for a collaborative programme involving Hawker and the Northrop Corporation to produce P.1127s for the US Army foundered in 1963–64, but in 1969 a licence agreement was signed by Hawker (now Hawker Siddeley) and McDonnell Douglas for the building of a batch of Harriers for the US Marine Corps. The costs of transferring production facilities for the relatively small number of aircraft involved (just over 100) led however to the surprising decision to buy the aircraft straight off the Kingston production lines, and deliveries began in March 1971. Designated AV-8A, the USMC Harrier differed only in minor detail from the GR.1, and the two-seat TAV-8A is likewise closely similar to the T.2. All have the Pegasus Mk 103, and most of the aircraft currently in service have been upgraded to AV-8C standard with the fitting of lift-improvement devices, chaff/flare dispensers and RWR.

The only other Harrier sale has been that made to the Spanish Navy, involving eleven single- and two two-seaters and conducted, for political motives, via the US Navy. These AV-8S and TAV-8S Matadors, as they are named, are flown from the elderly, wooden-decked ex-US Navy light carrier *Dedalo* and when ashore are based at Rota, near Cadiz. There appeared to be a reasonable prospect of supplying Harriers to the People's Republic of China at one time, and plans were laid with a view to a licence-production agreement, but nothing materialised. Navalised Sea Harriers are operated by India as well as by the Royal Navy's Fleet Air Arm, and at the time of writing there seems to be every chance that the Italian Navy will also buy these aircraft, provided interservice arguments about who flies what can be resolved.

Development of the Harrier concept continues apace, aimed at augmenting performance (notably radius of action) and weapons capabilities. The upshot, after yet more UK Government vacillation, has been a transfer of the initiative in V/STOL technology from Kingston to St Louis and the entry into service of the McDonnell Douglas AV-8B. That is another story – and another AEROGUIDE.

Above: XV278 was one of the six development Harriers and was later employed to test the new nose profile for the Ferranti LRMTS equipment. Seen here also toting 68mm Matra rocket pods and 100-gallon combat tanks (painted sand and azure blue), the aircraft carries a mix of standard and low-visibility national insignia. *British Aerospace*

Left: A pair of AV-8A Harriers from VMA-231, US Marine Corps. The significant recognition feature of US-operated Harriers is the prominent tactical VHF antenna atop the fuselage. Other changes include provision for Sidewinder AAMs as standard, and avionics modifications. *British Aerospace*

Above: The AV-8Ss operated by the Spanish Navy are virtual copies of USMC Harriers but have an extra dorsal antenna to enable them to communicate with helicopters serving with the *Armada*. Operated by *Escuadrilla 008*, the aircraft are finished in an extremely attractive colour scheme of pale grey and white. *British Aerospace*

Right above: Optimised for use by the Royal Navy, the Sea Harrier is a straightforward development of the basic Harrier airframe, incorporating Blue Fox radar, permanent Sidewinder stations and a raised cockpit to fit it for its primary air-to-air role. The aircraft shot to prominence during the Falklands War, when in air combat sorties it accounted for over twenty enemy aircraft at no cost.

Right below: Currently in production for the US Marine Corps and the Royal Air Force, the AV-8B Harrier II represents the very latest in V/STOL technology. Changes from the standard Harrier are fundamental, and include a new, much larger wing of composite construction, greater fuel capacity and modern avionics. The Pegasus Mk 105 is based on the Mk 104 installed in the Sea Harrier, but engine modifications are far less radical than those applied to the airframe.

STRUCTURE

As already mentioned, its vectored-thrust powerplant has a unique influence on the design of the Harrier. Some things are obvious. One is the need to keep the engine – or, more precisely, the thrust line(s) of the engine – as near to the aircraft's centre of gravity as possible. The efflux from each of the four swivelling nozzles is very evenly distributed, and the latter are interconnected so as to turn in exact unison. Thus when the aircraft is supported purely by jet lift with the nozzles angled at 90 degrees, it is desirable that the weight of the airframe is equally distributed forward and aft of the thrust line. It follows that the engine has to end up somewhere in the middle of the fuselage, a constraint not placed on CTOL aircraft.

Another obvious restriction is the location of the wing: with downward-pointing nozzles, this clearly has to be mounted high on the fuselage, away from any possible interference from the hot gases. This in turn more or less rules out a wing-mounted main undercarriage since the legs would need to be exceptionally long (posing problems of stowage) and exceptionally strong (adding weight); such an arrangement would also compromise stores carriage. Some preliminary designs showed a conventional tricycle undercarriage gear, all three units retracting into the fuselage, but the P.1127 appeared with 'zero-track' main gear, with outriggers supporting the wingtips and retracting rearwards into fairings.

A third plain fact is that normal flying controls are utterly useless during the VTOL or hovering mode, so some other means of manoeuvring the aircraft had to be worked out. The answer was puffer jets (technical term: reaction control valves). There were four at first, bled directly (and constantly) off the engine and all pointing down, at wingtips, nose and tailboom, those at the front and rear capable of rotating to cope with yaw. For the production Harrier a more sophisticated system was devised, the RCVs at the wing tips offering upthrust or downthrust, separate yaw valves being introduced at the tail and all operating only in response to the pilot's requirements (he moves the control stick, as he would for wingborne flight).

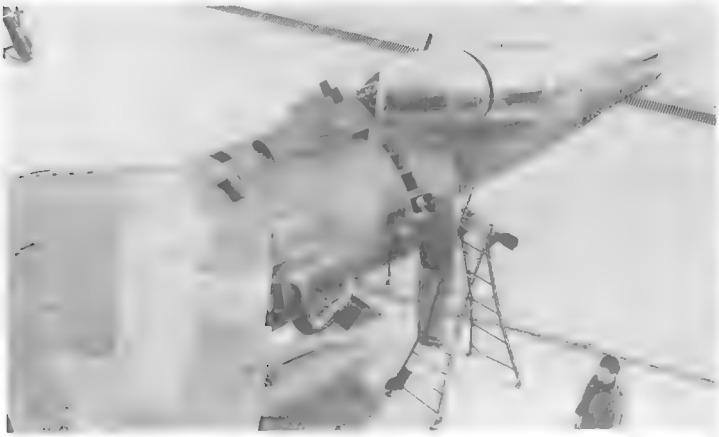
The enormous main intakes are each equipped with eight auxiliary blow-in doors to provide the extra air necessary during low-speed manoeuvres (and even flying tail-first). Further back, the Pegasus nozzles are aerodynamically faired, the hot (aft) efflux being kept clear of the fuselage by means of stainless steel shields. The rear fuselage houses the main avionics bay, the unusual location for this equipment being another result of the need to balance things around the engine.

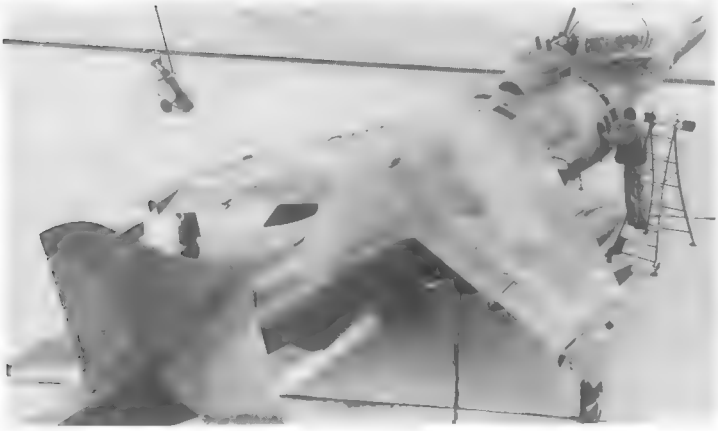
The wing is removable as one component, allowing the engine to be lifted out when necessary. Its movable surfaces are limited to simple ailerons and flaps, outboard and inboard respectively. The inboard wing sections double as integral fuel tanks (total 345 gallons); five more tanks are distributed about the fuselage (total 285 gallons). In-flight refuelling is possible via a bolt-on probe but is generally carried out only during long-range ('ferry') deployments (*ie* not very often). With the same sorts of operations in mind, Harrier engineers produced redesigned, enlarged wing tips, for substitution in place of the standard low-level tips, to give improved cruise performance at altitudes beyond the aircraft's normal flight regime. However, these are used even less frequently.

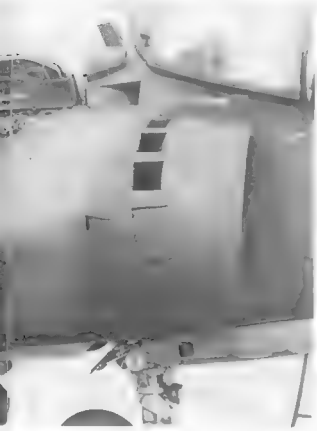
As the new GR Mk 5 (AV-8B) enters service, it is proposed that RAF GR.3s (and presumably T.4s) be updated with new nav/attack equipment, an ECM system and provision for air-to-air self-defence. A significant change in external appearance is likely, with the fitting of wing leading-edge root extensions (LERX), to improve the Harrier's manoeuvrability in the air.

Opposite page: Harrier GR Mk 3 XZ993/'04' (one of the last single-seat aircraft delivered to the RAF), No 1 Squadron, RAF Wittering, February 1985. Although records indicate that this aircraft did not take part in the Falklands War, it is fitted with the I-band transponder housing and blade antenna beneath the nose, to enable British aircraft carriers to get a positive 'fix' on it and thus aid recovery aboard ship.
Above: Low-angle head-on views of two GR.3s, the aircraft on the right showing the I-band transponder bulge. The Ferranti laser ranger and marked-target seeker (LRMTS) fitted in the extended nose has its head protected by shutters ('eyelids') when not in use; painted black, these quickly weather to expose the underlying zinc chromate primer.
Below: The LRMTS 'Snoopy' nose also houses the Harrier's 70mm reconnaissance camera, which is angled slightly downwards and faces to port.

This page: Forward fuselage and canopy details, GR Mk 3; the No 1 Squadron badge is well in evidence. Rescue stencilling appears in both English and German, a requirement of German law for military aircraft that are based (or might be based) in the Federal Republic. The inflatable intake blanks are a comparatively recent introduction to the Harrier fleet. Made of PVC, they provide an additional safety margin over the old 'solid' type in the event of an accidental engine start. The central flap provides access to the pressure valve. The sliding canopy is fitted with the usual miniature detonating cord (MDC).
Opposite page top: Port main intake, showing the eight auxiliary doors that enable the Pegasus engine to gulp extra air when needed. The plumbing and attachment points for the in-flight refuelling probe can be made out on top of the intake.
Opposite page bottom: A view over the port wing, showing the arrangement of the control surfaces.

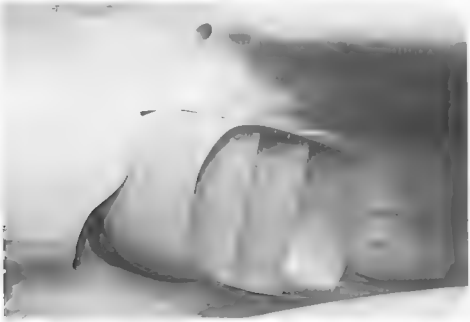


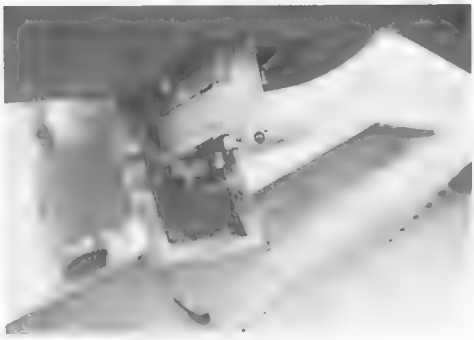




This spread: Angles on the 'T-bird'. The RAF machines shown here are from No 1 Squadron and No 233 OCU; the Fleet Air Arm Harrier (bottom right) is one of the recently-delivered T Mk 4Ns, operated by 899 Naval Air Squadron at RNAS Yeovilton for Sea Harrier type-conversion. Prominent behind the rear cockpit are the boundary layer air outlets; on the GR.3 these are located beneath the rear frame of the canopy and are thus not normally visible. The flat grilles on top of the fuselage are the intake (port) and exhaust (starboard) for the auxiliary power unit (APU), one of the functions of which is to start the main engine.

Above and below left: The Harrier's swivelling jet nozzles, the 'spider' of the Pegasus visible through the rearmost unit. The forward ('cold') nozzles have angle scales painted on the fuselage nearby. In the wing root leading edge, next to the small intake, is a light for illuminating the refuelling probe during night-time transfers.
Below right: Starboard wing reaction control valve (RCV), located in the undercarriage outrigger fairing. T Mk 4.
Bottom left: Detail view showing the ventral air brake. Immediately behind this is the retrofitted chaff dispenser unit, with battery access panel and safety key. Prior to this fit, during the Falklands conflict, Harriers flew with chaff wedged in bundles in the air brake bay itself.
Bottom right: Engine monitoring cassette tape, XW768/'08'.

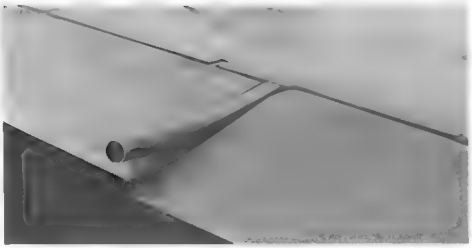




Above: Harrier GR Mk 3 XZ969/'01', No 1 Squadron, RAF Wittering, February 1985, in standard camouflage. The aircraft code is repeated on the outrigger wheel fairings, and the squadron emblem on the nose comprises a winged figure '1'
Below: A Harrier about to be moved back to its hangar by a Mercedes Unimog towing truck. The photo clearly shows the stub fences and vortex generators along the wing

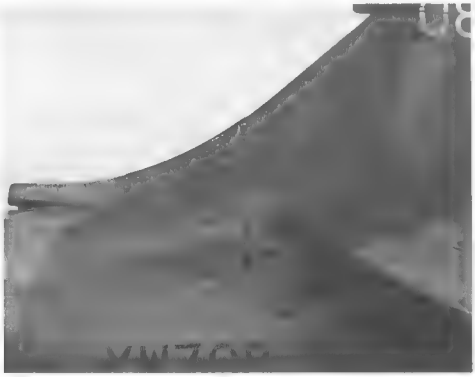
Overleaf: A hive of activity on the No 1 Squadron flight line The aircraft are plugged in to the Houchin's splitter box to keep their batteries charged, practice bombs are about to be unloaded from the armourers' Land Rover trailer, and a refuelling bowser waits to top up '04's tanks; the ever-present CO_2 fire extinguishers are to hand should they be needed. The camouflage patterns, though similar, are not identical

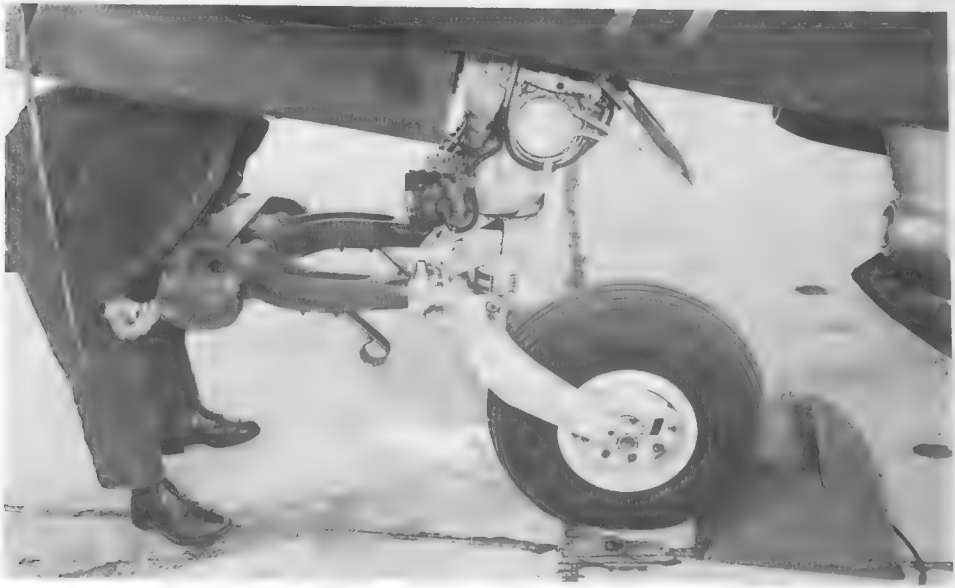
Above: An interesting view of Harrier T Mk 4 XW270 '12', attached to No 1 Squadron. Noteworthy are the tinted main windscreen, the drooped tailplane and the staining behind each of the wing vortex generators **Left:** Harrier T.4 XW934/'W', August 1983; the garb of the attendant groundcrewmen and the yellow-painted fuel bowsers in the background indicate that this photograph was taken at RNAS Yeovilton The No 233 OCU insignia is well illustrated, and of special interest is the fact that the aircraft is about to be flown on instruments only – note the black-out screens across the main windshield.

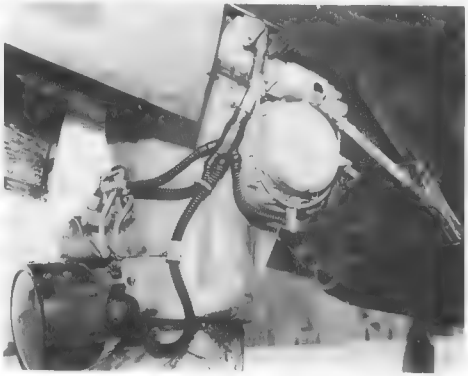


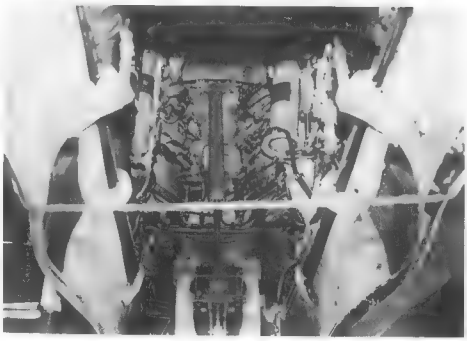
Top: Rear fuselage of GR.3 XZ969/'01'. The airbrake is evidently a replacement component, incompatibly coded 'S' on its inner surface.
Above left: Fuel jettison pipe, starboard wing.
Above right: Ram air turbine (RAT) in extended position, Harrier T Mk 4. This item is now being removed from RAF Harriers.
Left: T.4 rear fuselage, showing the tail 'sting' characteristic of two-seaters. The fin, too, differs from that of the single-seat Harrier in having an 11in extension to its base, the increased area aiding stability. Some T Mk 2s had extended tips to their fins; all trainers have a ventral fillet.

Right: Rear aspect of GR.3 XW768/'08', emphasising the anhedral of the Harrier's wings and tailplane. Fitted to the port side of the fin are a total outside temperature (TOT) probe and, beneath, an Engine Usage Monitoring System (EUMS) probe; EUMS is not fitted to all aircraft.
Below: Tailfin detail, GR Mk 3. The HF notch antenna at the base of the fin is over-painted on some aircraft.
Bottom: Tail boom of the Harrier T.4 (left) contrasted with that of the GR.3 (right). Common to both are the RCVs, tail lights and, at the extreme tip, the rearward-looking RWR.
Opposite page: Four views of the nose undercarriage gear. The cord visible in three of the photos connects the main intake blanks, ensuring that one cannot be removed without the other. A towbar is being positioned in the top photograph.



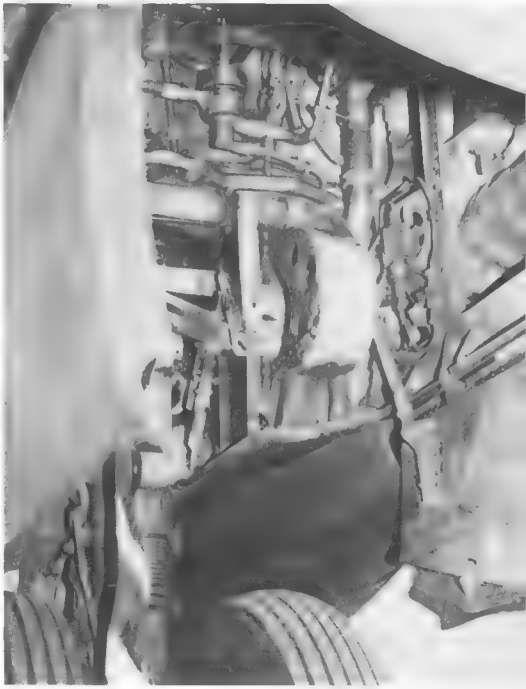


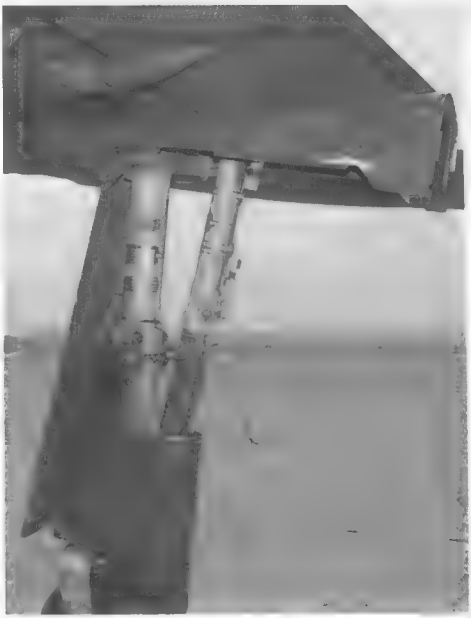




This page: Harrier main undercarriage unit. The doors are generally to be seen closed whilst the aircraft is parked but may be opened manually to permit maintenance etc. The dangers of FOD (foreign object damage) apply to undercarriage bays as well as engine intakes, particularly in the case of the Harrier with its downward-blasting efflux.

Opposite page: The 'bicycle' or 'zero-track' main undercarriage is balanced by a pair of outrigger units which retract backwards for flight. Some GR.3s (not two-seaters) have shackles fitted, identifying the aircraft earmarked for carrier operations (although not necessarily those which took part in the Falklands War). Individual aircraft codes are carried on the hinged outrigger fairing, in yellow in the case of No 1 Squadron machines, and the flap nearby provides access to the outrigger knuckle joint. The RCVs exhaust through the fixed portion of the fairing.





MISSION

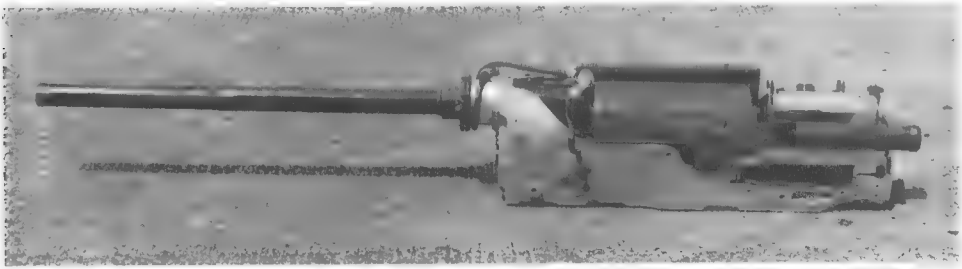
The Harrier is designed to operate in the low-level tactical strike and reconnaissance role, flying from air bases, roadways or dispersed 'field' sites, rural or urban, close to the enemy front line. Primary objectives are described as battlefield air interdiction, close air support and tactical reconnaissance. Radius of action is typically in the region of 150–250 miles, but these figures assume STO; VTO reduces considerably either the radius over which the aircraft can operate or the weight of stores that can be taken aloft (or both, depending on the fuel/weapons requirements of the individual mission) and in general is not practised. VL, involving a returning and hence lighter aircraft, is not disfavoured, and indeed could prove mandatory in the event of a conflict.

In theory, and now assuming full rolling take-offs, up to 8000lb of weapons or stores can be carried, but 5000lb is rarely exceeded. All carriage is external, via four underwing and one underfuselage pylons, plus two fuselage attachment points for pods containing the trusty 30mm Aden cannon (which the USMC were happy to keep for their AV-8As). Compatible stores include standard 1000lb 'iron' GP bombs; Hunting BL.755 cluster bombs; Matra Type 115 68mm multiple rocket (SNEB) pods; Lepus flares; and 100-gallon combat tanks. Larger, 330-gallon 'ferry' tanks may be carried if required. The Falklands War of April–June 1982 saw emergency clearance for the carriage of AIM-9L Sidewinder air-to-air missiles, 1000lb Pave Way laser-guided bombs, standard Royal Navy (2in)

rocket pods and 190-gallon fuel tanks. For the reconnaissance role, the fixed F.95 70mm camera (nose-mounted, facing to port) can be supplemented by a five-instrument centreline pod. Pylon ratings are 2000lb (centreline, inboard wing) and 1000lb (outboard wing).

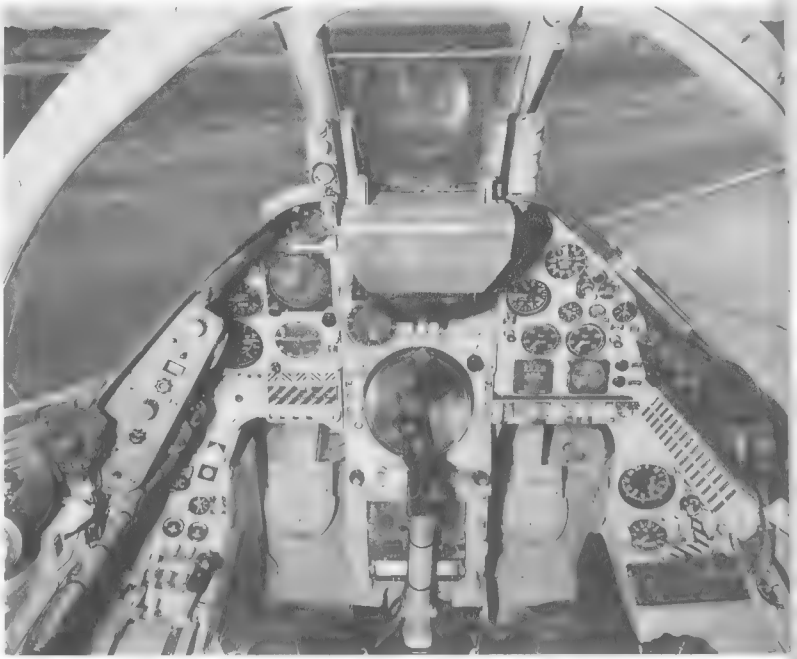
Aiding the pilot in his mission is an avionics suite which was, in large measure, developed originally for the stillborn P.1154. The Smiths Industries head-up display (HUD) is prominent above the pilot's main instrument panel, providing him with basic flight information (speed, heading, attitude, weapons status etc) projected directly in his normal field of view through the windscreen by means of electronic symbols. To aid navigation, a projected map display (head-down) occupies the centre of the main panel: a pre-selected map is loaded in film cassette form and moves in response to the aircraft's actual position, giving constant 'present position' and heading information via the navigation display computer. Central to these displays is the Ferranti FE.541 navigation/attack system, another P.1154 fit. Externally, the most apparent piece of avionics is the Ferranti laser ranger and marked-target seeker (LRMTS). Stabilised against aircraft movement, this provides accurate and continuously updated range data on battlefield targets or can pinpoint hidden targets designated ('marked') by ground-based forward air controllers, acquiring reflected laser energy from the FAC's field equipment. This capability was put to use with effect during the Falklands conflict.

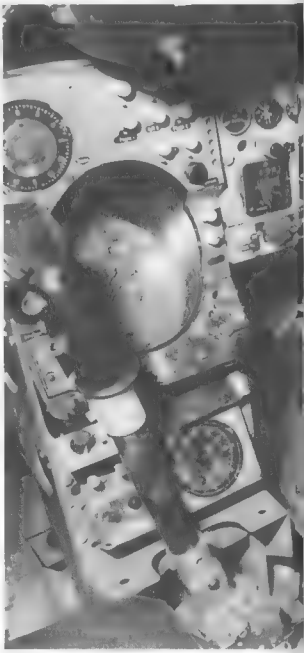
Opposite page: A scene aboard the aircraft carrier *Hermes* during the Falklands War. The Harrier GR.3 in the foreground, XZ997/'31', has Pave Way laser-guided bombs fitted to its outboard pylons. *British Aerospace*
Above: A No 4 Squadron Harrier GR.3 takes to the air with a weapons load comprising seven Hunting BL.755 cluster bombs. Each bomb contains 147 'bomblets'. *Richard L Ward*
Left: Matra Type 115 68mm rocket pods receive attention from Harrier ground crewmen. Eighteen rockets are installed in each pod here, the centre tubes being left vacant. *British Aerospace*
Below: ML Aviation twin carriers equipped with Lepus flares, shown fitted to a Harrier GR.1. *ML Aviation*

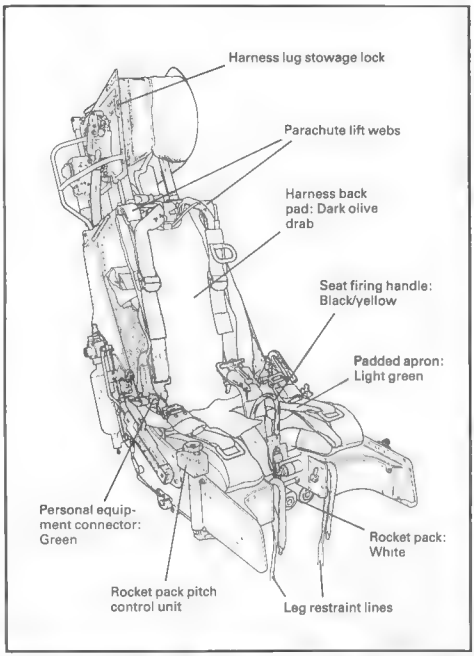


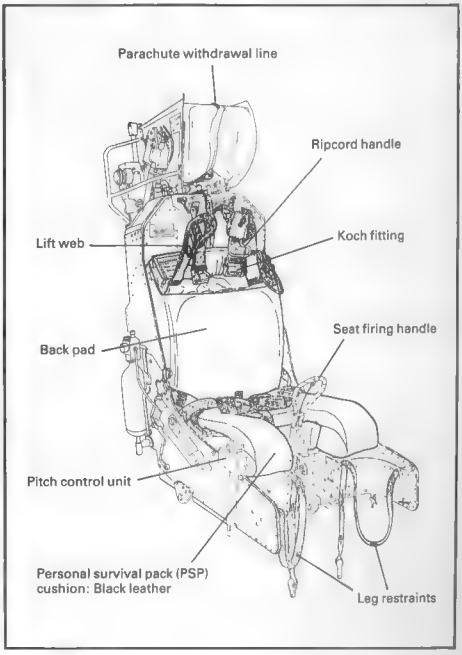
Opposite page top: Although Harriers are cleared for 230-gallon underwing tanks, the type most commonly seen is the 100-gallon variety, as here. The tailfins for these tanks are generally no longer fitted – mainly because they kept falling off!
Opposite page centre: The Aden 30mm cannon, two of which can be carried beneath the fuselage in podded mountings. There is provision for 150 rounds per gun. *British Aerospace*
Opposite page bottom: Close-up view of the Harrier's outboard pylon.
Above: Armourers load the centreline practice bomb carrier of a No 1 Squadron Harrier; the aircraft is a two-seat trainer, as can be seen by the ventral fin at the far right of the photograph. The Aden cannon fairings have a secondary role as lift-improvement devices (LIDs) and when not fitted are replaced by shallow strakes which perform the same function.
Left: The practice bombs for the Harrier shown above are brought out to the flight-line in cases, towed to position by the armourers' Land-Rover.

Right: What the Harrier pilot sees. Dominating the main instrument panel is the head-up display (HUD), giving him line-of-sight electronic information as he flies. *British Aerospace*
Below: The throttle box, located to the pilot's left, incorporates the nozzle controller. *British Aerospace*
Below centre: The starboard console, with TACAN, voice-recorder and IFF controls. All these cockpit views are of a GR Mk 3. *British Aerospace*
Opposite page top: Two views of the Type 9A Mk 2 ejection seat as fitted to the Harrier GR.3. The T.4's rear seat (Type 9D2 Mk 2) is generally similar, but the front seat fitted to the trainer (Type 9D1 Mk 2) differs in that its canopy breaker is of a modified design – see photos on pages 14 and 15. *Martin-Baker Aircraft Co*
Opposite page bottom right: Type 9D2 Mk 2 seat with early-pattern harness, now replaced in all Harriers except for some operating in Belize. *Martin-Baker Aircraft Co*






Harness lug stowage lock
Parachute lift webs
Harness back pad: Dark olive drab
Seat firing handle: Black/yellow
Padded apron: Light green
Personal equipment connector: Green
Rocket pack: White
Rocket pack pitch control unit
Leg restraint lines


Parachute withdrawal line
Ripcord handle
Lift web
Koch fitting
Seat firing handle
Back pad
Pitch control unit
Personal survival pack (PSP) cushion: Black leather
Leg restraints

SQUADRON SERVICE

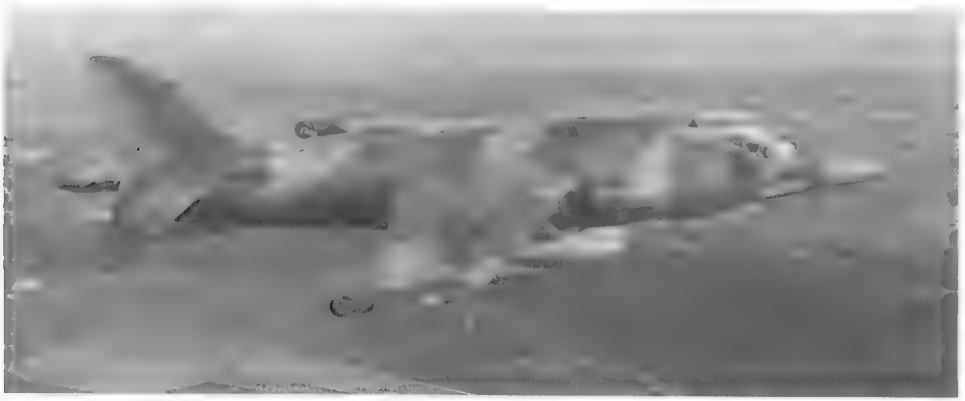
A total of 118 single-seat Harriers have been built for the Royal Air Force, 78 GR Mk 1s (of which 56 were later modified to GR Mk 3 standard) and 40 new-build GR Mk 3s. Eighteen two-seaters have been produced, ten T Mk 2s, two Mk 2As and six Mk 4s; most T.2/2As were subsequently brought up to Mk 4 standard, and most of these were fitted with LRMTS and RWR.

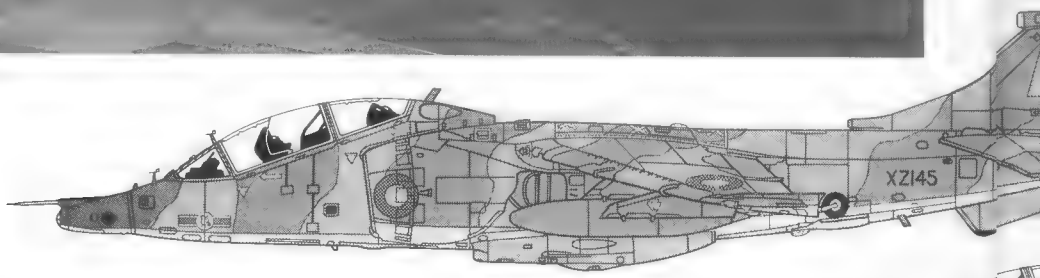
Service personnel began to familiarise themselves in earnest with the Harrier in January 1969 with the formation of the Harrier Conversion Unit, and, as related elsewhere, the first front-line squadron to go V/STOL was No 1(F). In due course the HCU was restyled No 233 Operational Conversion Unit. Both No 1 Squadron and the OCU set up shop at RAF Wittering, and 'The Home of the Harrier' has continued to host these two units through to the present time.

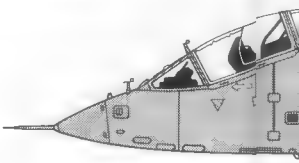
The next front-line squadron to convert to Harriers was No 4(F), based in West Germany and encompassing photo-reconnaissance as a speciality. This would also have been the last Harrier unit to form had it not been for a decision to extend the production run from the original sixty airframes. Piecemeal orders have for long been the hallmark of British defence procurement and, true to form, a second batch of seventeen machines was sought in due course, for service with No 20(F) Squadron, another RAFG unit. No 20 began to take delivery of Harriers in 1971, but six years later the unit converted to Jaguars in an administrative shake-up. Meantime another small batch was procured in order that a fourth front-line unit, No 3(F) Squadron RAFG, could be equipped. Nos 3 and 4 Squadrons are both based at Gütersloh, close to the East German border.

Many of the sqadrons' activities are, as may be expected, concerned with training in, and evaluation of, operations from dispersed sites close to potentially hostile territory. Some of these sites are large enough to permit STO operating techniques, whilst others can only support VTO. Back-up facilities at the sites also vary, from full communications and logistics support, through fuelling and arming only, to nothing at all. Constant practice and experience over fifteen years have enabled the Harrier squadrons to perfect off-base missions, in conjunction particularly with No 18 Squadron Chinook and No 230 Squadron Puma helicopters (also based at Gütersloh) and with RAF Regiment Rapier SAM batteries.

Two other Harrier units have been formed, drawing aircraft from the main squadrons. Following the Falklands War of 1982 a detachment of Harrier GR.3s was headquartered at RAF Stanley until the opening in 1985 of the new Mount Pleasant Airport enabled rapid reinforcement by CTOL combat aircraft to take place if required. Designated No 1453 Flight, the unit originated out of the GR.3s sent south to fly from the carrier *Hermes* on sorties against Argentine-held positions. Further to the north, in Central America, No 1417 Flight has since 1979 been based in Belize, stationed at the International Airport (but also using nearby dispersed sites), to make neighbouring Guatemala think twice about carrying out its oft-repeated

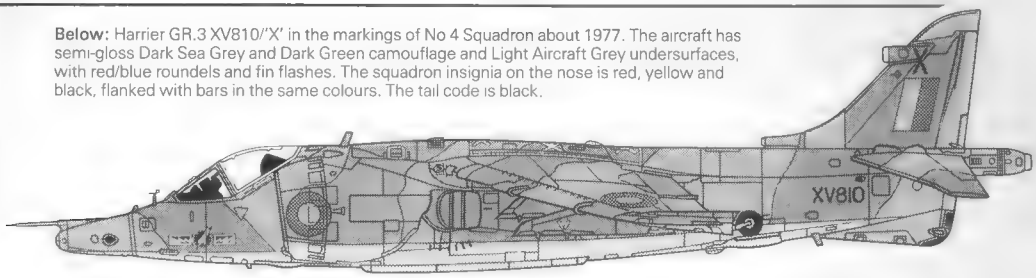






Above: Harrier T Mk 4 XZ145/'T' in the now defunct scheme of Dark Sea Grey and Dark Green uppersurface camouflage with Light Aircraft Grey undersides. The No 3 Squadron insignia is red and grey on a white disc, with dark green and yellow flanking bars. The fin code is yellow.
Right: Harrier T Mk 4N of the Fleet Air Arm's 899 Naval Air Squadron, 1984–85. The finish is overall glossy Dark Sea Grey, with serial numbers, codes and squadron insignia black. Note the standard red outline to the main engine access panel on top of the fuselage. The Royal Navy operates three of these trainers; type conversion was previously carried out using RAF aircraft.

Below: Harrier GR.3 XV810/'X' in the markings of No 4 Squadron about 1977. The aircraft has semi-gloss Dark Sea Grey and Dark Green camouflage and Light Aircraft Grey undersurfaces, with red/blue roundels and fin flashes. The squadron insignia on the nose is red, yellow and black, flanked with bars in the same colours. The tail code is black.



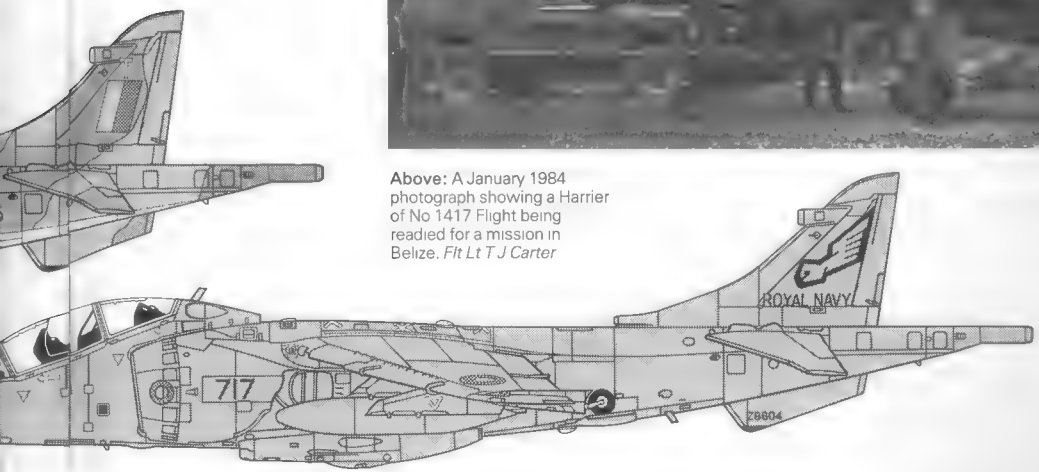
threat to invade and conquer the British protectorate.

RAF Harriers, since their entry into service, have been painted in the low-level tactical camouflage scheme of the day, this consisting of a disruptive pattern of Dark Sea Grey and Dark Green. The paintwork was originally glossy, and the aircraft's undersurfaces were finished in a contrasting Light Aircraft Grey, but since about 1971 a matt finish has been standard (with the white areas deleted from the national insignia), and from the late 1970s the undersides of the aircraft have also been painted in disruptive grey/green camouflage. Unit badges are presented low on the nose and fuselage roundels on the main intakes, across the 'blow-in' doors, whilst recent years have witnessed the gradual deletion of underwing serials. Major stencilling (rescue information etc) appears in both English and German; even on UK-based Harriers this is apparent, owing to the rotation of aircraft around the squadrons.

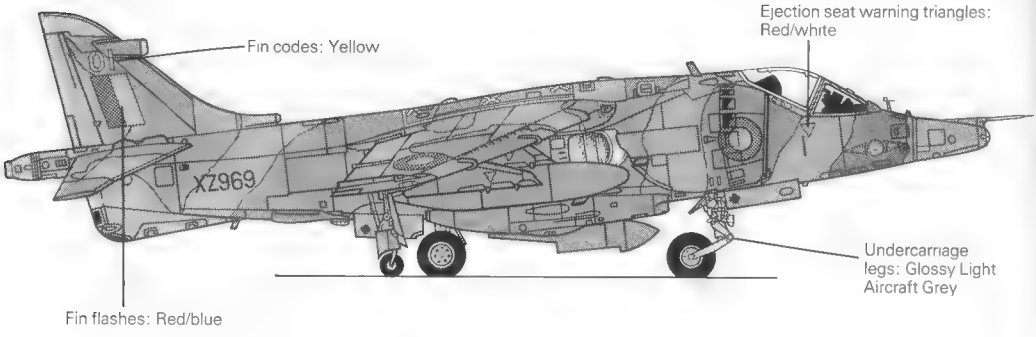
The Harrier has always been in the forefront of public attention: its unique capabilities could hardly have meant otherwise, but the political shilly-shallying surrounding its development and the deluge of cynical criticism from so-called experts whose chief object in life appears to have been to promote a campaign of denigration against it have combined to ensure that the aircraft has constantly been the subject of controversy. Meanwhile, in service, the RAF has quietly gone about its business of honing V/STOL operations to perfection.

Left: A Harrier GR Mk 3 from No 20 Squadron RAF, with plenty of streaking over its wings caused by deposition in the lee of the vortex generators. The camouflage pattern avoids cutting across the aircraft's movable surfaces, thus avoiding problems of matching up replacement parts. This particular aircraft, XZ135/'P', appears to have problems with its starboard outrigger wheel. *RAF Official*

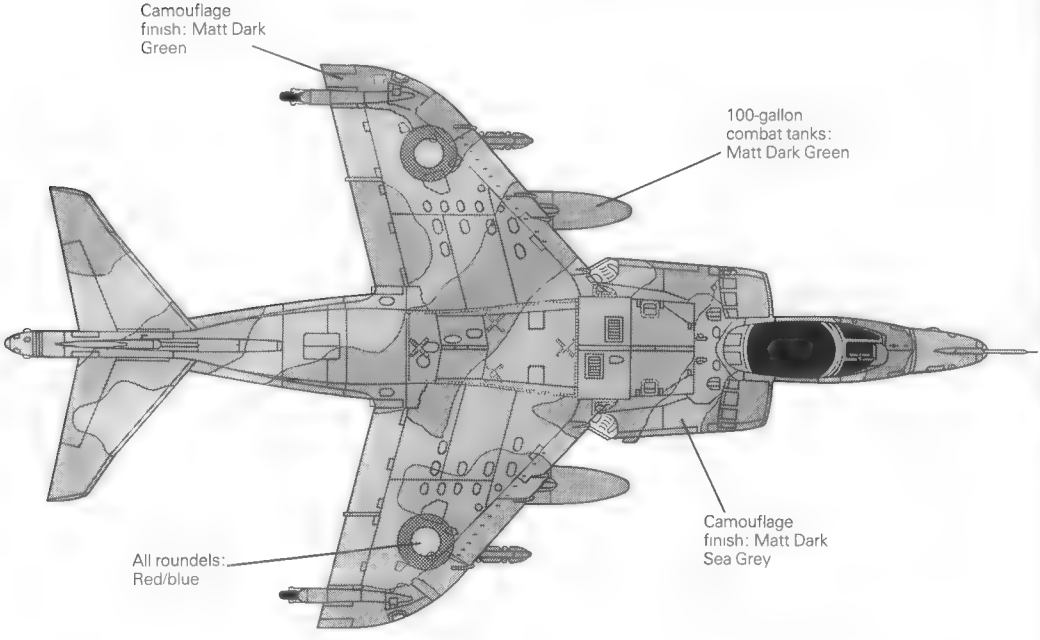
Above: A January 1984 photograph showing a Harrier of No 1417 Flight being readied for a mission in Belize. *Flt Lt T J Carter*



HAWKER SIDDELEY HARRIER GR Mk 3, No 1(F) SQUADRON, RAF WITTERING, FEBRUARY 1985

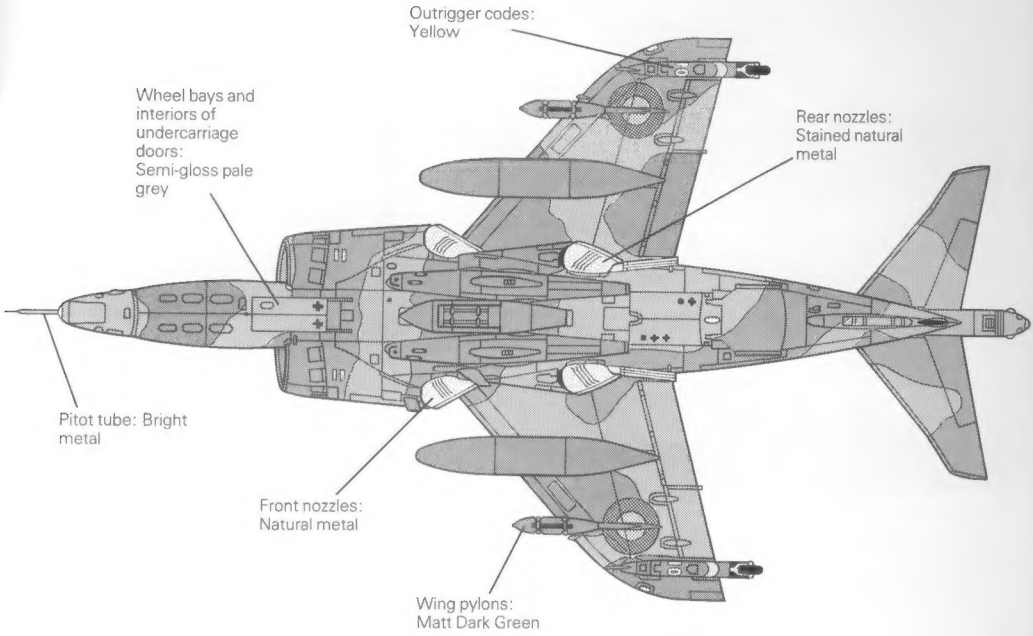


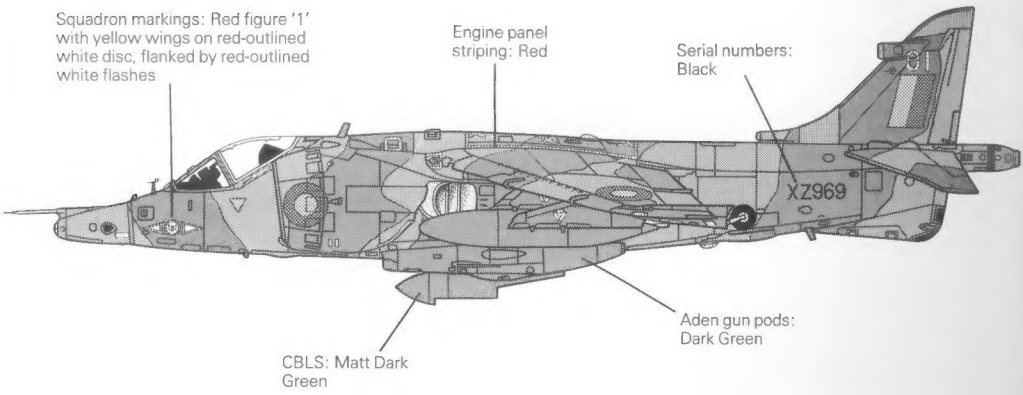
For further information on Harrier colour schemes and markings see Modeldecal sets 15, 23, 46, 75 and 78



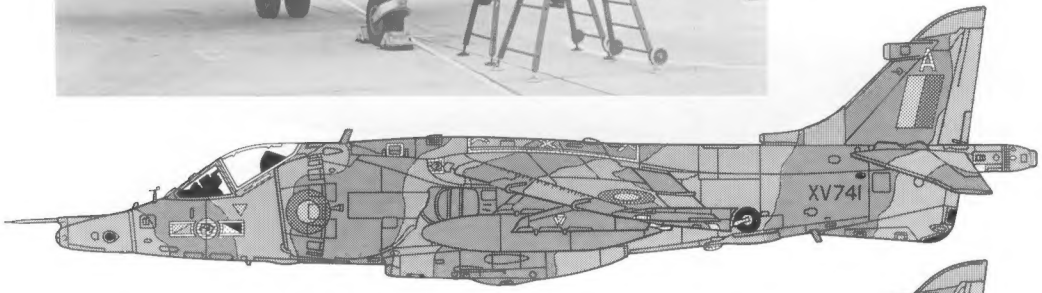
British Standard Colour (BSC) references
Dark Sea Grey: BS381C-638
Dark Green: BS381C-641

1:72 scale

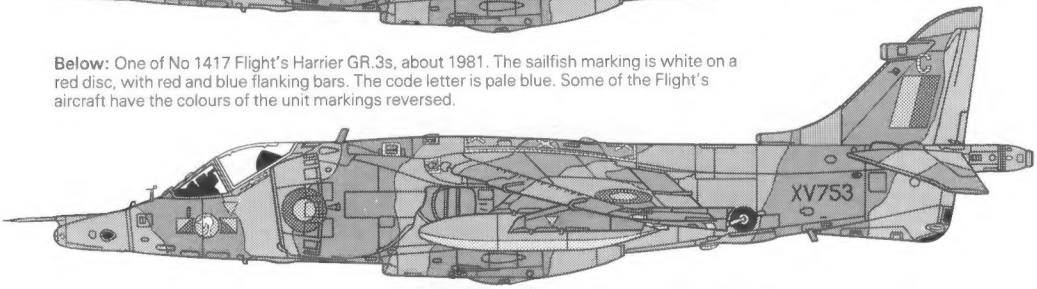

Outrigger codes: Yellow
Wheel bays and interiors of undercarriage doors: Semi-gloss pale grey
Rear nozzles: Stained natural metal
Pitot tube: Bright metal
Front nozzles: Natural metal
Wing pylons: Matt Dark Green


Squadron markings: Red figure '1' with yellow wings on red-outlined white disc, flanked by red-outlined white flashes
Engine panel striping: Red
Serial numbers: Black
XZ969
Aden gun pods: Dark Green
CBLS: Matt Dark Green

Left: Pre-flight checks for a Harrier T Mk 4 of No 233 Operational Conversion Unit.
Below: No 233 OCU also operates a number of single-seat Harriers. This GR Mk 3, XV741/'A', shows the full wrap-around camouflage currently worn by all RAF Harriers. The unit marking is black, white and grey on a pale blue disc, the flanking bars being segmented in red and grey (left) and yellow and black (right) and outlined in pale blue (which colour is also used for the fin code).



Below: One of No 1417 Flight's Harrier GR.3s, about 1981. The sailfish marking is white on a red disc, with red and blue flanking bars. The code letter is pale blue. Some of the Flight's aircraft have the colours of the unit markings reversed.



Left: Wg Cdr Peter Squire (No 1 Squadron) lands the first Harrier GR.3 aboard *Hermes* for operations against Argentine positions, 19 May 1982. This particular machine, XZ988/'34', was lost to ground fire eight days later. The unit markings on the nose have been obliterated, as has the fin code, although the code numerals remain on the outrigger fairings. Fourteen Harrier GR.3s were sent south for Operation 'Corporate'; the aircraft were used in the strike and reconnaissance roles but not in air-to-air combat, provision for which had however been made by fitting the outer pylons for Sidewinder missiles. *British Aerospace*

Hawker Siddeley Harrier GR Mk 3

Linewrights Ltd

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